NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ESDS Reuse Working Group

Reuse Tools to Help Enable Climate Research in NASA Missions

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Abstract

Reusing software from current NASA missions can contribute to the data processing capabilities of the Earth science decadal survey missions and other future decadal-like missions focused on the Earth's climate and natural systems. The use of tools and recommended standards and practices, such as NASA's Reuse Readiness Levels (RRLs) to assess, identify, and categorize reusable software assets helps to reduce risk and cost of the development of mission software. Incorporating reuse practices in the software development process enables its timely construction and permits more time for developers to innovate and enhance the solution for the target science user community. RRLs and other such tools are applicable as far upstream as the mission Science Information Processing Systems (SIPS), all the way to the Distributed Active Archive Centers (DAACs) and to ad-hoc analyses conducted downstream by individual scientists and investigators.

A Reuse Enablement System (RES) offers capabilities to register and track software assets from previous missions that have potential for reuse in future missions. The RES can facilitate capabilities to reuse software and architectural components that are being developed for the decadal survey missions for possible use in future missions. The RES is also a mechanism to capture RRL assessments directly on a per-asset basis during the mission lifecycle. Exploring and incorporating software assets into a software development project also serves to educate and train developers on techniques proven effective for similar purposes. We expect the RES, RRLs, and other reuse enablement mechanisms to assist decadal missions in their software development lifecycles and to form a framework for the effective and efficient development of mission software, on-time, and within acceptable risk parameters and cost estimates, in the years to come.

Reuse Readiness Levels (RRLs)

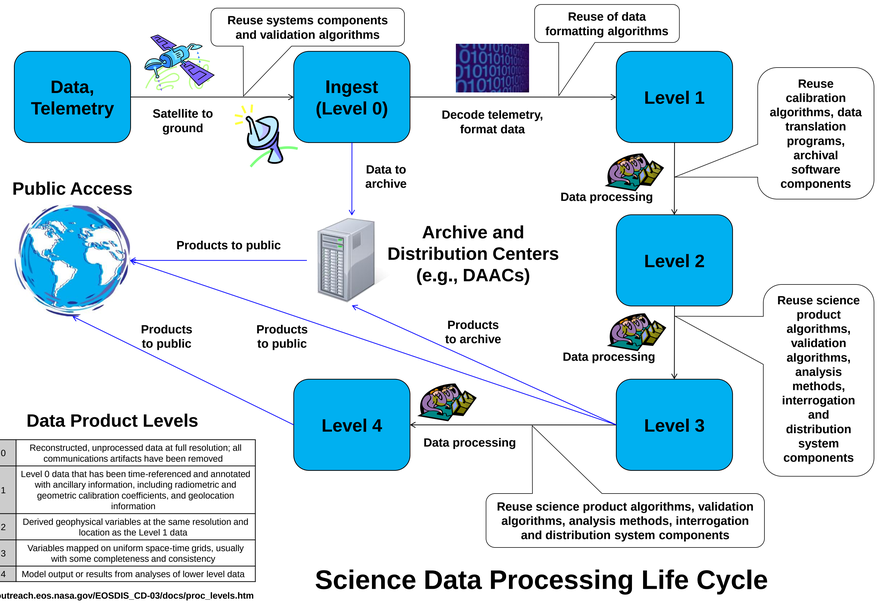
RRLs can be used to assess software under development or software being considered for adoption. The above left table shows the overall levels, which are useful for quick assessments and/or a general view of an asset's reuse maturity. The above right table shows the nine topic area levels from which the overall RRLs were derived. These topic area levels can provide a more granular assessment of an asset's reuse maturity.

Reuse Readiness Levels (RRLs)

Level	Summary	Description
RRL 1	Limited reusability; the software is not recommended for reuse.	Little is provided beyond limited source code or pre-compiled, executable binaries. There is no support, contact information for developers or rights for reuse specified, the software is not extensible, and there is inadequate or no documentation.
RRL 2	Initial reusability; software reuse is not practical.	Some source code, documentation, and contact information are provided, but these are still very limited. Initial testing has been done, but reuse rights are still unclear. Reuse would be challenging and cost-prohibitive.
RRL 3	Basic reusability; the software might be reusable by skilled users at substantial effort, cost, and risk.	Software has some modularity and standards compliance, some support is provided by developers, and detailed installation instructions are available, but rights are unspecified. An expert may be able to reuse the software, but general users would not.
RRL 4	Reuse is possible; the software might be reused by most users with some effort, cost, and risk.	Software and documentation are complete and understandable. Software has been demonstrated in a lab on one or more specific platforms, infrequent patches are available, and intellectual property issues would need to be negotiated. Reuse is possible, but may be difficult.
RRL 5	Reuse is practical; the software could be reused by most users with reasonable cost and risk.	Software is moderately portable, modular, extendable, and configurable, has low-fidelity standards compliance, a user manual, and has been tested in a lab. A user community exists, but may be a small community of experts. Developers may be contacted to request limited rights for reuse.
RRL 6	Software is reusable; the software can be reused by most users although there may be some cost and risk.	Software has been designed for extensibility, modularity, and portability, but software and documentation may still have limited applicability. Tutorials are available, and the software has been demonstrated in a relevant context. Developers may be contacted to obtain formal statements on restricted rights or to negotiate additional rights.
RRL 7	Software is highly reusable; the software can be reused by most users with minimum cost and risk.	Software is highly portable and modular, has high-fidelity standards compliance, provides auto-build installation, and has been tested in a relevant context. Support is developer-organized, and an interface guide is available. Software and documentation are applicable for most systems. Brief statements are available describing limited rights for reuse and developers may be contacted to negotiate additional rights.
RRL 8	Demonstrated local reusability; the software has been reused by multiple users.	Software has been shown to be extensible, and has been qualified through test and demonstration. An extension guide and organization-provided support are available. Brief statements are available describing unrestricted rights for reuse and developers may be contacted to obtain formal rights statements.
RRL 9	Demonstrated extensive reusability; the software is being reused by many classes of users over a wide range of systems.	Software is fully portable and modular, with all appropriate documentation and standards compliance, encapsulated packaging, a GUI installer, and a large support community that provides patches. Software has been tested and validated through successful use of application output. Multiple statements describing unrestricted rights for reuse and the recommended citation are embedded into the product.

RRL Topic Area Summaries

	Documentation	Extensibility	Intellectual Property Issues	Modularity	Packaging	Portability	Standards Compliance	Support	Verification and Testing
Level 1	Little or no internal or external documentation available	No ability to extend or modify program behavior	Product developers have been identified, but no rights have been determined.	Not designed with modularity	Software or executable available only, no packaging	The software is not portable	No standards compliance	No support available	No testing performed
Level 2	Partially to fully commented source code available	Very difficult to extend the software system, even for application contexts similar to the original application domain	Developers are discussing rights that comply with their organizational policies.			Some parts of the software may be portable	No standards compliance beyond best practices	Minimal support available	Software application formulated and unit testing performed
Level 3	Basic external documentation for sophisticated users available	Extending the software is difficult, even for application contexts similar to the original application domain	Rights agreements have been proposed to developers.	Modularity at major system or subsystem level only	Detailed installation instructions available	The software is only portable with significant costs	Some compliance with local standards and best practices	Some support available	Testing includes testing for error conditions and proof of handling of unknown input
Level 4	Reference manual available	Some extensibility is possible through configuration changes and/or moderate software modification	Developers have negotiated on rights agreements.			The software may be portable at a reasonable cost	Standards compliance, but incomplete and untested	Moderate systematic support is available	Software application demonstrated in a laboratory context
Level 5	User manual available	Consideration for future extensibility designed into the system for a moderate range of application contexts; extensibility approach defined and at least partially documented	Agreement on ownership, limited reuse rights, and recommended citation.	Partial segregation of generic and specific functionality	Software is easily configurable for different contexts	The software is moderately portable	Standards compliance with some testing	Support provided by an informal user community	Software application tested and validated in a laboratory context
Level 6	Tutorials available	Designed to allow extensibility across a moderate to broad range of application contexts, provides many points of extensibility, and a thorough and detailed extensibility plan exists	Developer list, recommended citation, and rights statements have been drafted.			The software is portable	Verified standards compliance with proprietary standards	Formal support available	Software application demonstrated in a relevant context
Level 7	Interface guide available	Demonstrated to be extensible by an external development team in a similar context	Developer list and limited rights statement included in product prototype.	Clear delineations of specific and reusable components	OS detect and auto-build for supported platforms	The software is highly portable	Verified standards compliance with open standards	Organized/defined support by developer available	Software application tested and validated in a relevant context
Level 8	Extension guide and/or design/developers guide available	Demonstrated extensibility on an external program, clear approach for modifying and extending features across a broad range of application domains	Recommended citation and intellectual property rights statement included in product.				Verified standards compliance with recognized standards	Support available by the organization that developed the asset	Software application "qualified" through test and demonstration (meets requirements) and successfully delivered
Level 9	Documentation on design, customization, testing, use, and reuse is available	Demonstrated extensibility in multiple scenarios, provides specific documentation and features to build extensions which are used across a range of domains by multiple user groups	Statements describing unrestricted rights, recommended citation, and developers embedded into product.	All functions and data encapsulated into objects or accessible through web service interfaces	Installation user interface provided	The software is completely portable	Independently verified standards compliance with recognized standards	Large user community with well-defined support available	Actual software application tested and validated through successful use of application output



Data Product Levels

Level 0	Reconstructed, unprocessed data at full resolution; all communications artifacts have been removed
Level 1	Level 0 data that has been time-referenced and annotated with ancillary information, including radiometric and geometric calibration coefficients, and geolocation information
Level 2	Derived geophysical variables at the same resolution and location as the Level 1 data
Level 3	Variables mapped on uniform space-time grids, usually with some completeness and consistency
Level 4	Model output or results from analyses of lower level data

http://outreach.eos.nasa.gov/EOSDIS_CD-03/docs/proc_levels.htm

Science Data Processing Life Cycle

For more information about the WG and its activities, please visit:
http://www.esdswg.com/softwarereuse

Reuse Enablement System (RES)

The RES is designed to provide information about and easy access to reusable Earth science software assets. This can help developers achieve the benefits of reuse by encouraging systematic reuse, in part by providing them with a known location at which to discover reusable assets. Below are three screenshots of the initial prototype RES: at left, the home page as viewed by an anonymous visitor; at center, the full detail page for an asset as viewed by a Provider; at right, the administrator's interface. Some features of the RES are highlighted by red boxes.

Home page as viewed by an Anonymous User

Other highlights:
- When logged in, a menu bar appears above the reuse banner.
- Registered users can sign up for notifications.

On the main downloads page (not pictured), Consumers would also see this note :

Note: You currently do not have the ability to upload files. If you would like to do so, find out how to become a provider!

Full detail page for an asset (Provider view)

Administrator menu for Downloads module configuration